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IEEE Standard Requirements for Conversion of Power Switchgear Equipment

IEEE Power Engineering Society

Sponsored by the
Switchgear Committee

IEEE

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IEEE Standard Requirements for Conversion of Power Switchgear Equipment

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Switchgear Committee
of the
IEEE Power Engineering Society

Approved 22 January 2003
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IEEE-SA Standards Board

Abstract: Directions and requirements are provided for the conversion of qualified power switchgear equipment. Examples such as low-voltage power circuit breakers; high-voltage outdoor and medium-voltage indoor drawout power circuit breakers; low- and medium-voltage fused contactors; low- and medium-voltage ground and test devices; medium-voltage fused load interrupter switches; and all metal-enclosed switchgear are covered. Existing design standards are referenced with appropriate guidance on design testing necessary to design-verify the conversions. Reconditioning, which concerns the maintenance of existing equipment without alteration, is not covered.
Keywords: conversion, power switchgear equipment, qualified design

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Introduction

(This introduction is not part of IEEE Std C37.59-2002, IEEE Standard Requirements for Conversion of Power Switchgear Equipment.)

This revised standard covers conversions of power switchgear equipment only, rather than a complete power switchgear equipment replacement. A conversion of power switchgear equipment reuses some portion of the qualified design switchgear.

This standard has been revised to correct some specific reference errors; to separate low-voltage and medium-voltage conversions for clarity; to include low and medium-voltage ground and test (G&T) devices; to clarify nameplate modification and additions; to include conversion of low- and medium-voltage circuit breakers to alternating current fused contactors and conversion of interrupter switchgear to add or substitute power fuses. It has also been revised to stress the importance of drawout interlocking and auxiliary functions known to have caused field problems.

Converted circuit breakers may or may not be interchangeable with existing non-converted circuit breakers. Where converted circuit breakers are not interchangeable with non-converted circuit breakers, it will be so indicated in the converter's instruction book and the blocking/rejection interlock shall be changed.

It is stressed that at least the minimum tests recommended and outlined in specific references are to be carried out as applicable on each differing design (or model) of a converted device. Reliance only on production tests with statements that the conversion has been "ANSI tested," unsubstantiated by formal documented design verification, can mislead users and may result in field failures. Production tests are not design tests. The basic and fundamental philosophy of this standard is that a converted product is a new design and must be design verified to substantiate that it meets its nameplate ratings as well as applicable standards. A recommended design verification form is included.

The lack of design verification of some conversions was the reason for the creation of the original (1991) version of this document. Experience gained with use of the original document and the 1996 revision has been incorporated into this revision of the standard.

There are many forms of conversion, and this document provides the logic that should cover all power switchgear equipment conversions, with examples of current areas of conversion and testing. As additional types of switchgear products are converted, criteria for the new conversion products will be added in future revisions of this standard.

Annex A, though not a normative part of this standard, is provided for guidance in the design verification of the converted power switchgear equipment. It provides additional guidance regarding conversion examples and the minimum testing required for design verifications.

Examples of components that may be converted include, but are not limited to:

Circuit breakers

- Frame
- Insulation structures
- Contacts, supports, and primary disconnecting devices
- High-voltage arc-interrupting structures
- Low-voltage arc-interrupting structures

NOTE—This includes substitution of low-voltage and medium-voltage alternating current fused contactors in place of circuit breaker elements.

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— Low-voltage direct-acting trip device systems
— Drawout parts/interlocking and auxiliary functions
— Mechanism parts and control wiring

Switchgear vertical sections

— Drawout parts/interlocking and auxiliary functions
— Frame
— Bus, bus connections, and insulation
— Instrumentation and control wiring

Ground and test devices

Metal-enclosed interrupter switchgear

— Addition or substitution of power fuses

This standard is not intended to cover maintenance procedures when reconditioning power switchgear equipment in accordance with the manufacturer's instruction manuals.

Participants

The Administrative Subcommittee (ADSCOM) Working Group of the IEEE Switchgear Committee that prepared and approved this standard had the following membership:

Peter W. Dwyer, *Chair*

Ted A. Burse	Albert Livshitz	Michael Orosz
Harpinder S. Gill	Nigel P. McQuin	Robert J. Puckett
Keith I. Gray	Ted W. Olsen	Gerald Sakats
Ward E. Laubach		Alan D. Storms

The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

W. J. Bergman	John G. Leach	Vincent Saporita
Stan Billings	David Lemmerman	Devki Sharma
James E. Bowen	Albert Livshitz	M. Dean Sigmon
Ted A. Burse	R. W. Long	Ned Simon
Carlos L. Carbrera-Rueda	Gregory Luri	H. Melvin Smith
Gura Dutt Dhingra	Nigel P. McQinn	R. Kirkland Smith
Alexander Dixon	Daleep C. Mohla	James E. Smith
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Ruben D. Garzon	Paul J. Notarian	Alan D. Storms
Douglas H. Giraud	George R. Nourse	David Swindler
Mietek T. Glinkowski	Ted W. Olsen	Chand Z. Tailor
Keith I. Gray	Michael Orosz	Stan H. Telander
Randall C. Hess	Gordon O. Perkins	Malcolm V. Thaden
Richard Jackson	Robert J. Puckett	Michael Wactor
Jerry M. Jerabek	Radhakrishna V. Rebbapragada	Charles L. Wagner
Joseph L. Koepfinger	David N. Reynolds	James W. Wilson
P. L. Kolarik	Hueh C. Ross	Robert Vanniello
Thomas W. LaRose	Gerald Sakats	Larry E. Yonce
Ward E. Laubach	Lawrence Salberg	Janusz Zawadzki

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Peter H. Lips
Nader Mehravari
Daleep C. Mohla
William J. Moylan
Malcolm V. Thaden
Geoffrey O. Thompson
Howard L. Wolfman
Don Wright

*Member Emeritus

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IEEE Standard Requirements for Conversion of Power Switchgear Equipment

1. Overview

This standard covers power switchgear equipment that is converted from a qualified design. It provides direction and guidance in those conversions and specifies required design verification in accordance with applicable American National Standards Institute (ANSI), National Electrical Manufacturers Association (NEMA), Underwriters Laboratories Inc. (UL), or IEEE standards.

This standard also recognizes that production/field testing does not provide design verification. This can only be accomplished by means of design testing and technical evaluation.

1.1 Scope

Present industry conversions involve low- and medium-voltage power circuit breakers used in metal-enclosed and metal-clad switchgear; low- and medium-voltage fused contactors; switchgear vertical sections; power fuse addition or substitution in metal-enclosed interrupter switchgear, and certain ratings of other circuit breakers. This document outlines criteria for conversion of this type of equipment.

This standard cannot detail each test that must be carried out to qualify a conversion. The specific tests shall be selected by the converter considering exact changes made from the previously qualified design. The converter shall conduct thorough and formal design verification for the completed conversion, and shall perform all additional tests determined to be necessary.

A vital part of the circuit breaker conversion process is the electrical and mechanical coordination of the mechanism-operated cell (MOC) switches with the converted circuit breaker to ensure proper operation. New, sealed interrupter modular units may have much less mechanism power than that of the circuit breakers they replace, and may not have the ability to operate all installed MOC switches. Accordingly, this may necessitate substantial revision to or replacement of the MOC switches and their operating linkage in the existing vertical sections to assure proper operation.

Any conversions performed on third-party labeled, or listed equipment, or equipment requiring Nuclear Regulatory Commission conformance will void the label, listing, or certification of the equipment. It will be necessary to reapply to the third party for continued certification of the equipment. For instance, typical examples are: if any UL -listed switchgear assembly is converted to use molded case circuit breakers in place of UL- listed power circuit breakers, the converted switchgear assembly must be submitted to the UL, and if a UL- listed low-voltage power circuit breaker is converted to change the electro-mechanical series trip units to an electronic type trip unit, the converted breaker must be submitted to UL.

A converter shall not knowingly convert a design which he knows to be defective without taking or recommending appropriate action to correct the defect in any assembly being converted.

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1.2 Other conversions

The conversion and testing processes outlined in this standard are based on known examples and are outlined for general guidance and direction. However, alterations can be made to other equipment, not discussed in detail in this document, that will require design verification in accordance with appropriate standards. Whenever there is any question, the converter should be consulted.

Additionally, while this standard specifically does not cover reconditioning of power switchgear equipment, it does recognize the process and the fact that appropriate production/field testing is necessary.

2. References

The following standards are referred to in this document and are the most recently published editions of the standards. When a standard is superseded by an approved revision, the revision shall apply. However, when conversions are made to older total current rated circuit breakers, it is essential that the converted device ratings are correlated to at least meet the applicable ratings and design requirements of the original circuit breaker designs described in the appropriate edition of the standard.

2.1 Low-voltage equipment

ANSI C37.16-2000, American National Standard Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors—Preferred Ratings, Related Requirements, and Application Recommendations.[1]

ANSI C37.17-1997, American National Standard for Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers.

ANSI C37.50-1989 (R2000), American National Standard for Switchgear—Low-Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures.

IEEE Std C37.13™-1990 (R1995), IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.[2, 3]

IEEE Std C37.14™-1999, IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures.

IEEE Std C37.20.1™-2002, IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

NEMA ICS 2-2000, Industrial Control and Systems: Controller, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.[4]

NFPA 70-2002, National Electrical Code® (NEC®).[5]

UL 489 (2002), Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enlosures.[6]

UL 508 (1999), Industrial Control Equipment.

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[1]ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

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[5]NFPA publications are published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, USA (http://www.nfpa.org/).

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2.2 Medium- and high-voltage equipment

ANSI C37.06-2000, American National Standard for Switchgear—AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities.

ANSI C37.58-1990 (R1996), American National Standard for Switchgear—Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear—Conformance Test Procedures.

IEEE Std C37.04™-1999, IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers.

IEEE Std C37.09™-1999, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

IEEE Std C37.20.2™-1999, IEEE Standard for Metal-Clad Switchgear.

IEEE Std C37.20.3™-2001, IEEE Standard for Metal-Enclosed Interrupter Switchgear.

IEEE Std C37.20.4™-2001, IEEE Standard for Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear.

IEEE Std C37.20.6™-1997, IEEE Standard for 4.76 kV to 38 kV Rated Grounding and Testing Devices Used in Enclosures.

NEMA ICS 3-1993 (R2000), Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC).

UL 347 (1993), High-Voltage Industrial Control Equipment.

2.3 Miscellaneous

IEEE Std C37.100™-1992 (R2001), IEEE Standard Definitions for Power Switchgear.

NEMA ICS 1-2001, Industrial Control & Systems: General Requirements.

3. Definitions

The definitions contained in this standard are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this standard.

If a term is not defined in this standard, the definition in IEEE Std C37.100-1992 applies.[7] The following definitions are not contained in, or differ from the definitions in, IEEE Std C37.100-1992.

3.1 blocking/rejection interlock: A mechanical device which prevents the insertion of removable elements into a compartment with incompatible ratings or MOC operating capabilities.

3.2 conversion: The process of altering existing power switchgear equipment from any qualified design.

3.3 design verification: The process of design qualification, in accordance with all appropriate standards, of any conversion by means of design testing and/or evaluation, supported by justified technical evaluation and documentation.

[7]Information on references can be found in Clause 2.

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3.4 modular assembly: A circuit breaker element including interrupters, operating mechanism, and connecting terminals, or an alternating current (ac) contactor element including interrupters, operating mechanism and connecting terminals, or a molded case circuit breaker.

3.5 qualified design: Any power switchgear equipment which has been tested and certified to appropriate industry standards.

3.6 racking: The act of moving a removable element physically between the connected position and the disconnected positions in its compartment.

3.7 reconditioning: The process of maintaining existing power switchgear equipment in operating condition as recommended by the manufacturer's instructions, using only the qualified design parts. Reverse engineered parts (designs copied from existing parts by other manufacturers) are not considered to be "qualified design parts" unless specifically design verified.

3.8 replacement interchangeable circuit breaker: A circuit breaker that utilizes all new parts has been design tested to IEEE Std C37.09-1999 or ANSI C37.50-1989 as required, and requires no conversion of existing switchgear to maintain proper operation.

3.9 replacement non-interchangeable circuit breaker: A circuit breaker that utilizes all new parts and has been design tested to IEEE Std C37.09-1999 or ANSI C37.50-1989 as required, but requires conversion of existing switchgear to maintain proper operation.

3.10 retrofill: A conversion process that includes replacement of the circuit breaker and circuit breaker compartment functional components of a qualified design within a vertical section or compartment of a vertical section with functional components of a different qualified design.

4. Service conditions

The service conditions specified in the standards listed in Clause 2 apply to new equipment. Older equipment shall meet the service conditions in the standards that were in effect at the date of its manufacture unless the specified conversion process alters the equipment to meet the service conditions in the referenced standards. Any new and/or unusual service conditions shall be specified by the user.

5. Ratings

The ratings of new equipment are covered by the standards listed in Clause 2. The ratings of older equipment are covered by the standards that were in effect at the time of its manufacture. Converted equipment shall continue to meet the original ratings unless different ratings are specified and/or accepted by the user. All ratings shall be documented on the nameplate. Appropriate blocking/rejection interlock features are also required. When a circuit breaker is converted to a higher rating, the existing switchgear must also be evaluated for capability at this higher rating.

6. Conversion and testing

The conversion process can involve as little as a minor frame change to replacing main or arcing contact tips with other than the qualified design material, or replacing the entire arc-interrupting structure and mechanism. This clause outlines known, specific examples of conversion, with the minimum testing required to verify the conversion. When multiple alterations are made, design tests may be combined for overall evaluation.

Design testing is required in accordance with the applicable standards listed in the References (Clause 2). Metal-enclosed devices shall be tested in their applicable switchgear enclosures as required by the

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referenced standards. Since alterations can affect the overall operation of the equipment, design verification of conversions is necessary.

All interlocking and MOC switch functions are critical to proper operation and shall be design verified in an enclosure duplicating the intended installation. Additional design testing may be necessary when converted circuit breakers are required to be interchangeable with existing non-converted circuit breakers. Applicable portions of design tests can be utilized, with justified technical evaluation of the design alterations, to ensure that performance has not been adversely affected. Test data from previous similar qualified designs can be used for current designs, if clearly technically applicable.

Design verification data and the justified technical evaluation shall be available to the user, on request, to ensure that the converted equipment has been tested in accordance with this standard for continued service under installation conditions.

Any alterations to breaker or switchgear to accommodate a new trip device must not violate NEC Article 240, paragraph 240-6(c) for “restricted access” when applicable.

6.1 Circuit breakers and related conversions

6.1.1 Frames

Any alterations to the circuit breaker frame require design verification in accordance with ANSI C37.50-1989 or IEEE Std C37.09-1999.

To ensure that all interlocking and auxiliary functions have been retained, racking tests shall be made in the original switchgear enclosure or in an enclosure duplicating the original in accordance with IEEE Std C37.20.1-2002 or IEEE Std C37.20.2-1999 for design verification. All metal-enclosed, dead-front features present in the qualified design, shall be retained.

6.1.2 Insulation structures

The insulation structure provided to support current-carrying parts or connecting bushings is specifically designed for mechanical strength as well as electrical and thermal life. Any alteration shall require design verification in accordance with ANSI C37.50-1989 or IEEE Std C37.09-1999.

6.1.3 Contacts, supports, and primary disconnecting devices

Any alteration in the qualified design or manufacturing process of contacts, contact structures, contact supports, arc chutes or arc runners, or primary disconnecting devices, including material composition, brazing or plating, can affect overall performance and shall require design verification in accordance with ANSI C37.50-1989 and IEEE Std C37.20.1-2002 or IEEE Std C37.09-1999 and IEEE Std C37.20.2-1999.

6.1.4 Medium- and high-voltage arc-interrupting structures

The arc-interrupting structures are designed to control and extinguish arcs. Conversion possibilities are given in the examples in 6.1.4.1 and 6.1.4.2.

6.1.4.1 Retaining the original structure (air-magnetic, air-blast, oil, etc.)

a) Any original manufacturer’s recommended replacement parts or other qualified design replacement parts utilized must still be design verified.
b) Air-magnetic circuit breaker arc-chute materials including splitter plates and liner plates are critical to proper operation and shall not be changed without a complete series of short-circuit current rating design tests in accordance with IEEE Std C37.09-1999.

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6.1.4.2 Conversion of the qualified structure (air-magnetic, air-blast, oil, etc.)

When an interrupter conversion is made to a circuit breaker, there are several alternatives that vary in complexity as outlined in the following examples:

a) Conversions utilizing individual interrupters to replace only the interrupting structure and contacts require basic circuit breaker design changes such as the insulating structures for mounting and/or mechanism parts to modify stroke and force.

   This type of conversion shall be subjected to the complete series of design tests in accordance with IEEE Std C37.09-1999 and IEEE Std C37.20.2-1999 to verify the circuit breaker for the ratings assigned.

b) Conversions utilizing a modular assembly may require alterations to the original circuit breaker frame to mount the modular assembly as well as to provide connections to the existing or new primary bushings, and may require revisions to insulation structures or components.

The modular assembly shall be subjected to the complete series of design tests in accordance with IEEE Std C37.09-1999. The design test data from the modular assembly tests may be utilized for design verification, if clearly applicable. Additional design tests shall be made on the complete conversion and shall include a dielectric withstand, momentary current, short-time current, continuous current, interlock, and other operational tests including tests to verify correct function with MOC switch assemblies, if applicable (see IEEE Std C37.20.2-1999 and 6.1.7.2 of this standard).

Mechanical endurance testing of the converted circuit breaker is required to at least the “between servicing” operational level requirements listed in ANSI C37.06-2000. If the circuit breaker has no MOC switch operator, it may be tested separately but if a MOC switch operator is involved, it must be tested in the connected position in a duplicate of the switchgear vertical section to the same level.

In certain cases, the orientation and proximity of the bus connections between the modular units and the connection bushings can affect the short-circuit current capability of the sealed interrupters due to changes in magnetic fields around the interrupters. Sufficient short-circuit current testing shall be conducted for verification unless all configurations have been evaluated and documented by previous testing.

6.1.5 Low-voltage

Conversion of low-voltage power circuit breakers may include the following types of alterations:

— Changing arc-interrupting structure (arc chutes) to eliminate asbestos.
— Replacement of an earlier design circuit breaker with a different design mounted on the same drawout structure.
— Replacement of electro-mechanical or electronic trip devices with a different electronic trip system.
— Addition of fuses to an unfused circuit breaker.
— Substitution of different current limiting fuses on a fused circuit breaker.
— Replacement of arc-interrupting structure with a fused ac contactor element.

6.1.5.1 Arc-interrupting structure

When ac or direct current (dc) low-voltage circuit breaker arc chute designs are altered in any way, a complete series of short-circuit current and dielectric design tests shall be conducted in accordance with ANSI C37.50-1989 for ac types and IEEE C37.14-1999 for dc types.

6.1.5.2 Circuit breaker substitution

When the existing circuit breaker is replaced with a different circuit breaker design utilizing the same circuit breaker frame structure, complete design tests shall be performed in accordance with ANSI C37.50-1989, IEEE C37.14-1999, UL 489 (2002) and IEEE Std C37.20.1-2002.

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6.1.5.3 Fuse addition or substitution

When fused low-voltage circuit breaker current limiting fuses are changed from the exact model and rating initially qualified in the configuration, design verification shall be required in accordance with ANSI C37.50-1989. Dielectric withstand, continuous current, and short-circuit current tests shall be performed as appropriate to prove suitability of the application. It shall be verified by test that the maximum fuse let-through current does not exceed the capability of the circuit breaker without the fuse. When current limiting fuses are added to an originally unfused circuit breaker, an open-fuse trip device is required. A series of the dielectric withstand, continuous current and short-circuit current tests is also required regardless of the fuse rating. Dielectric testing is required to verify the ability of the fused conversion to satisfactorily withstand rated maximum voltage from either the line or load connections with blown, open or removed fuses. The test voltage shall be as specified by the appropriate apparatus standard.

6.1.5.4 Direct acting overcurrent trip devices

The conversion of low-voltage circuit breakers from electro-mechanical trip devices to electronic trip systems, or conversion of electronic trip systems with different electronic trip systems, may require alteration of the current-carrying structure, the sensor mounting, and the operating mechanism to adapt the new latch-tripping device, as well as the mechanical mounting of the electronic trip logic unit.

Design testing in accordance with ANSI C37.50-1989 and ANSI C37.17-1997 is required for each application of a trip system. All trip systems shall be installed and tested on the circuit breaker frame size for which they are intended to be applied. Upon successful design testing, production testing shall be performed in order to verify subsequent application.

6.1.6 Low-voltage and medium-voltage operating mechanism parts and control wiring

When operating mechanism parts are replaced with other than the manufacturer's recommended replacement parts, design verification is required in accordance with ANSI C37.50-1989 or IEEE Std C37.09-1999.

Control wiring replacements shall be in compliance with IEEE Std C37.20.1-2002 or IEEE Std C37.20.2-1999. The replacement wiring shall be at least the same insulation temperature rating, ampacity, dielectric withstand capability, and flexibility as the original, or as required by the converted control system design. It is specifically noted that, for medium-voltage conversions, the wiring shall be isolated from primary elements by grounded metal barriers with the exception of short lengths of wire at terminals, such as those of secondary disconnect devices or auxiliary switches, if provided on the conversions.

Wiring changes shall undergo the necessary continuity checks and a dielectric withstand test in accordance with ANSI C37.50-1989 and IEEE Std C37.20.1-2002, or IEEE Std C37.09-1999 and IEEE Std C37.20.2-1999, for design verification.

6.1.7 Low-voltage and medium-voltage drawout parts, racking mechanisms, interlocking and other operational functions

Drawout interlocking and auxiliary functions as outlined in IEEE Std C37.20.1-2002 and IEEE Std C37.20.2-1999 are critical for the operation of the circuit breaker and shall be design verified [see item b) in 6.1.4.2.]

Testing, including mechanical endurance, shall be conducted in an enclosure duplicating the intended installation to insure the proper operation of all interlocking and other operational features.

If interchangeability with existing circuit breakers is required, then additional alteration of existing vertical sections may be necessary and design verification is required. Mechanical and electrical interchangeability between converted circuit breakers and non-converted circuit breakers in a switchgear assembly may not be possible, for instance, due to changes in control schemes. See 6.1.8 concerning requirements for warnings, instructions and blocking/rejection.

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6.1.7.1 Racking interlock functions

When the conversions require changes in the racking mechanism, design verification is required in accordance with IEEE Std C37.20.1-2002 or IEEE Std C37.20.2-1999 as applicable. It is essential that the racking interlocking functions of the converted circuit breaker operate in an enclosure duplicating the intended installation. For instance, racking interlocking for circuit breakers originally equipped with solenoid-closing mechanisms shall be mechanically matched (electrical interlocking alone is not acceptable) with the new stored energy system to meet the requirements of IEEE Std C37.20.2-1999. During the racking procedure, the circuit breaker shall be open and closing shall be prevented unless the primary disconnecting devices are in full contact or are separated by a safe distance.

Regardless of the previous configuration of racking interlocks, all conversions shall be built in accordance with the requirements previously outlined although modifications in the vertical section may be required for this capability.

6.1.7.2 Mechanism-operated cell (MOC) switches or truck-operated cell (TOC) switches

If MOC switches or TOC switches are mounted in the vertical section, whether altered or not, design verification of the assembly is required in accordance with IEEE Std C37.20.1-2002 or IEEE Std C37.20.2-1999, and item b) in 6.1.4.2 of this standard.

A vital part of the conversion process is the coordination of the MOC switches with the converted circuit breaker to ensure proper operation. However, since the new, sealed interrupter, modular units may have much less mechanism power than the circuit breakers they replace, they may not necessarily have sufficient reserve power to operate all installed MOC switches. This may necessitate substantial revision to or replacement of the MOC switches and their operating linkage in the existing vertical sections to assure proper operation. The converted circuit breaker shall satisfactorily operate with the maximum number of MOC switch contacts and spring return mechanisms that are recommended by the converter to be installed.

If MOC switch operation is limited, a prominent warning label shall be affixed to the circuit breaker indicating the limitation, e.g., “This converted circuit breaker is not designed to operate a separate external auxiliary switch (MOC switch).” The instruction book and nameplate must also state limitations. The blocking/rejection interlock shall be changed.

The MOC switch functionality shall be addressed as part of the conversion by both the converter and the user.

6.1.8 Control circuit coordination

The modular units used in conversions may have operators with different operating characteristics than the original circuit breaker. These differences shall be taken into consideration, in cooperation with the user, to ensure total control and indication coordination and may require alteration or replacement of certain switchgear control circuit components.

The converter, in cooperation with the user of the equipment to be converted, shall determine any warnings, instructions and blocking/rejection that is needed for control circuit coordination at a particular installation. Instruction books shall also provide these warnings.

Changes to the control circuit in a breaker compartment may be required when replacing a solenoid-operated breaker with a stored energy breaker. Modifications to the control schemes in the breaker compartment shall not result in an unintended closing operation of the previous design qualified device and shall be addressed during the design verification process.

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6.1.9 Ground and test (G&T) devices

6.1.9.1 Medium-voltage G&T devices

Conversions of medium-voltage G&T devices shall conform to all the requirements of IEEE Std C37.20.6-1997 and IEEE Std C37.20.2-1999 to ensure that the devices have ratings and compartment capabilities no less than the circuit breaker they are intended to temporarily replace.

6.1.9.2 Low-voltage G & T devices

Since neither an ANSI nor IEEE standard exists for these devices, they are custom devices confirming to manufacturer's design requirements and ratings. They may be built in a configuration similar to those specified in IEEE Std C37.20.6-1997, but the testing and application requirements shall be in accordance with the applicable requirements of ANSI C37.50-1989 and IEEE Std C37.20.1-2002.

The converter shall determine the ratings of the G&T device to be converted from its nameplate, or if necessary, from the manufacturer. The converted device shall have these same ratings unless increased ratings have been requested. It must be recognized that the available short-circuit current rating of the device and its application cannot exceed the short-time rating of its compartment as specified in Table 2 of ANSI C37.16-2000. The ability of the device to close and carry its short-time rating for 0.5 seconds shall be demonstrated in a similar manner to the C-O portion of Test 8 of Table 3 in ANSI C37.50-1989. If it is not possible to demonstrate an available peak current on closing as described in subclause 3.9.3.3.3 of ANSI C37.50-1989, it may be demonstrated in a separate test. The ground connection system shall be tested in a similar manner to what is described in 7.3.2 of IEEE Std C37.20.6-1997 except that the testing period is 0.5 seconds and the available short-circuit current cannot exceed the short-time rating of the switchgear ground bus.

The converter shall furnish a mechanical interlock bar on the G&T device to prevent its inadvertent insertion into a circuit breaker compartment of the same frame size that has a higher available short-circuit current in accordance with Table 1 of ANSI C37.16-2000. The converter shall also modify or instruct the user on how to modify their compartments to allow the devices to be used in the proper compartments rated in accordance with their short-time ratings. This will also distinguish the converted devices from new devices and compartments that may become available in the future that will be capable of meeting these higher ratings.

6.1.10 Alternating current drawout fused contactors

Conversions of both low-voltage and medium-voltage circuit breakers to ac fused contactors, utilizing modular ac contactor assemblies cannot be related directly to basic ANSI or IEEE standards as circuit breakers are. The only available standards that can apply in some manner are the NEMA ICS Series, UL 347 (1993), and UL 508 (1999). However, since ac fused contactor conversions do occur and since they are somewhat similar to low-voltage fused circuit breakers, Clause 6.1.10.1 through 6.1.10.8 will provide guidance, using the fused low-voltage circuit breaker approach. Dielectric testing is required to verify any fused conversion's ability to satisfactorily withstand rated maximum voltage from either the line or load connections with blown, open or removed fuses. The test voltage level shall be as specified by the appropriate apparatus standard.

6.1.10.1 Frames

Alterations to basic circuit breaker frames shall be minimized and limited to those necessary to accommodate the qualified modular ac contactor, the current limiting fuse mountings, and the open fuse trip device for single phase protection adaptation. All drawout features including interlocks shall be maintained. A barrier shall be provided in front of and as part of the removable element to prevent access to primary energized parts when the compartment door is opened.

6.1.10.2 Insulation structures

Alteration to the insulating structure of the circuit breaker shall be limited to assure continued dielectric integrity. Medium-voltage ac fused contactors are not required to have an impulse withstand basic impulse

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insulation level (BIL) rating across the open contacts. Therefore, the insulation coordination of the total installation must be re-evaluated to assure compatibility with the dielectric capabilities of the converted switchgear assembly. The exposure to over-voltages at the point of application in the distribution system shall be evaluated, and action taken to coordinate the insulation strength of the converted switchgear assembly with expected over-voltages, and to determine if supplemental surge-protective devices are necessary.

6.1.10.3 Current carrying parts

The basic current carrying parts, including the primary/secondary disconnecting devices of the circuit breaker may be modified to allow proper performance of the fused contactor and the other components in the switchgear.

6.1.10.4 Modular assembly

The modular assembly shall be mounted within the basic circuit breaker frame with alterations kept to a minimum to maintain the mechanical and electrical integrity of the frame, the insulation structure and the current carrying parts.

6.1.10.5 Control wiring

The control wiring of the modular assembly, with the exception of the internal control wiring of the ac contactor, shall follow the requirements of 6.1.6.

6.1.10.6 Replacement interchangeable or non-interchangeable drawout assembly interlocking

The drawout parts/interlocking shall follow the circuit breaker conversion clauses (see 6.1.7 and 6.1.7.1). MOC switches, if used, shall receive specific design verification to prove reliability due to the lower actuation force of contactors. Drawout mechanical interlocking is required to prevent racking of a closed contactor and to prevent its electrical or mechanical closing during racking. In addition, the contactor shall also be electrically interlocked to block a closing signal during racking. Blocking/rejection interlocking shall be provided on all contactor conversions to prevent insertion into a like circuit breaker compartment or into non-compatible contactor compartments.

6.1.10.7 Control circuit coordination

Control circuit coordination shall be in accordance with 6.1.8 including an evaluation of the control circuit power supply's capability to operate the contactor conversion within its operating limits. The coordination of protection shall also be reviewed. For instance, if the original protection scheme utilized an instantaneous trip function, it shall be defeated to prevent the possible errors in coordination between the primary circuit fuse and the contactor during a short circuit interruption.

6.1.10.8 Testing

The NEMA Industrial Control Standards ICS 1-2001, ICS 2-2000 and ICS 3-1993 as well as UL 508 (1999) and UL 347 (1993) standards provide some overall guidance. However, short-circuit current testing qualification for low-voltage and medium-voltage ac fused contactors installed in metal-enclosed switchgear is not addressed in the existing standards. The principles in ANSI C37.50-1989 relating to testing of low-voltage fused circuit breakers shall be used as a guide in developing test requirements for low-voltage and medium-voltage ac fused contactors. ANSI C37.50-1989 specifically addresses the rated assigned maximum and cross-over short-circuit current levels to ensure fuse protection of the modular unit at its maximum peak current withstand level. Appropriate use of all of these documents can provide for a design verified conversion with complete testing including continuous current, mechanical endurance, dielectric withstand and short-circuit current ratings. Dielectric testing is required to verify any fused conversion's ability of the fused conversion to satisfactorily withstand rated maximum voltage from either the line or load connections with blown, open or removed fuses. The test voltage shall be as specified by the appropriate apparatus standard.

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6.2 Switchgear vertical sections

6.2.1 Vertical section

All design alterations to a switchgear vertical section require design verification. The following are examples:

a) Utilization of a non-interchangeable replacement circuit breakers or other conversions requires design alterations to fully coordinate with the vertical section interlocks and MOC and TOC switches. The resulting configuration shall be design verified.
b) Utilization of a circuit breaker completely tested to IEEE Std C37.09-1999, or to ANSI C37.50 -1989 to replace another design of circuit breaker requires functional component replacement and design alterations to install the circuit breaker in the existing vertical section. The completed vertical section conversion shall be completely tested to IEEE Std C37.20.2-1999 or IEEE Std C37.20.1-2002 (as applicable). Examples of functional components include, but are not limited to: primary and secondary disconnecting devices, racking (drawout) mechanism, interlocks, and interconnecting buses.
c) When a complete, newly fabricated vertical section is constructed for expansion of the switchgear or as a replacement for a damaged section, any alteration from the original design shall require design verification. The design verification for these alterations shall be in accordance with IEEE Std C37.20.1-2002, IEEE Std C37.20.2.-1999, or IEEE Std C37.20.3-2001.
d) Incorporation of a complete retrofill assembly of circuit breaker and compartment into an existing vertical section in place of the existing circuit breaker requires design verification of the new installation.

6.2.2 Bus, bus connections, bus supports, and insulation

The switchgear bus, bus connections, current transformers, and insulation structure design are a balanced mechanical, electrical, and thermal system as initially designed. If the switchgear assembly rating is to be increased for any reason, such as the installation of a converted circuit breaker of a higher rating, technical evaluation and test of the assembly are required to qualify this increased rating (see IEEE Std C37.20.1-2002, IEEE Std C37.20.2-1999, or IEEE Std C37.20.3-2001).

6.2.3 Drawout parts/interlocking and other operational functions

These basic functions shall be retained in the converted equipment and any alterations to the existing or converted circuit breakers require design verification in accordance with IEEE Std C37.20.1-2002, IEEE Std C37.20.2-1999, or IEEE Std C37.20.3-2001. When interchangeability between vertical sections is required, modification/alignment of all circuit breaker interfaces shall be performed. Interchangeability is not always possible with existing, non-converted circuit breakers and may require changes in the blocking/rejection interlock features. Blocking/rejection interlocking shall be provided on all conversions to prevent insertion of removable elements into non-compatible compartments.

Any replacement of moving parts with other than the original design parts of the above equipment requires design verification. This may include mechanical endurance and other tests in accordance with IEEE Std C37.20.1-2002, IEEE Std C37.20.2-1999 or IEEE Std C37.20.3-2001.

If the primary disconnecting device design is altered, testing shall be correlated with the circuit breaker testing (see 6.1.3) in accordance with IEEE Std C37.20.1-2002 or IEEE Std C37.20.2-1999 for design verification.

6.2.4 Instrumentation and control devices and wiring

When current or voltage transformers, MOC or TOC switches, or similar components are replaced or additions are made, they should be a duplicate of the original design wherever practical. Replacement MOC or TOC switches shall have electrical ratings (interrupting, current carrying, and mechanical endurance)

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equal to or greater than those they replace unless lower capabilities are accepted by the user and qualified for the application. Replacement wiring, terminal blocks and terminal connections shall be as described in IEEE Std C37.20.1-2002, IEEE Std C37.20.2-1999, and IEEE Std C37.20.3-2001, and of at least the same ampacity, dielectric withstand capability, and flexibility as the original. For metal-clad switchgear, the control wiring shall be isolated from primary circuit elements by grounded metal barriers, with the exception of short lengths of wire at secondary disconnect and current transformer terminals.

Any replacement of moving parts by other than the qualified design parts of the above equipment will require mechanical endurance tests as well as continuity checks and dielectric withstand tests for design verification in accordance with IEEE Std C37.20.1-2002, IEEE Std C37.20.2-1999 and IEEE Std C37.20.3-2001.

6.3 Interrupter switchgear fuse conversions

Possible conversions of metal-enclosed interrupter switchgear include addition of fuses to equipment not originally designed to have power fuses, and substitution of power fuses of a different type or rating than the equipment was designed for. Either type of conversion requires design verification.

a) Conversion to add power fuses to metal-enclosed interrupter switchgear which was not designed with power fuses requires design verification in accordance with IEEE Std C37.20.3-2001 and ANSI C37.58-1990. If previous design test data is not available for the converted configuration, additional design tests shall be made on the complete conversion and shall include dielectric withstand, continuous current, short-circuit current-carrying, momentary current, and short-time current tests. For current-limiting type power fuses, the short-circuit current tests shall be performed with designated power fuses with the maximum let-through current not exceeding the capability of the switch. For expulsion type power fuses, short-circuit current tests to verify that the operation of the fuse in the enclosure does not adversely affect the mechanical and dielectric integrity of the enclosure are required unless test data from previous tests on an equivalent configuration is available.

   Addition of power fuses to equipment not designed to have power fuses requires the addition of interlocks to conform to IEEE Std C37.20.3-2001. These interlocks prevent access to the power fuses unless the switch is open, and shall prevent closing the switch when the power fuses are accessible.

b) Conversion to substitute a different design of power fuses other than with which the equipment was designed, requires design verification in accordance with IEEE Std C37.20.3-2001, and ANSI C37.58-1990. If previous design test data is not available for the converted configuration, additional design tests shall be made on the complete conversion and shall include dielectric withstand and short-circuit current tests. For current-limiting type power fuses, the short-circuit current tests shall be performed with designated power fuses with the maximum let-through current for use with the switch. For expulsion type power fuses, short-circuit current tests to verify that the operation of the fuse in the enclosure does not adversely affect the mechanical and dielectric integrity of the enclosure are required unless test data from previous tests on an equivalent configuration are available.

7. Production testing

Production testing of all conversions shall be in accordance with the applicable referenced standards ANSI C37.50-1989 and IEEE Std C37.20.1-2002, or IEEE Std C37.09-1999 and IEEE Std C37.20.2-1999, or IEEE Std C37.20.4-2001 and IEEE Std C37.20.3-2001.

8. Nameplates

In order to ensure that the converted equipment performance ratings and responsibility for design are properly established, additional nameplates are necessary. Regardless of the complexity of the conversions,

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the original manufacturer's nameplate shall be retained on the equipment for traceability (safety recall and/or renewal parts) and a conversion nameplate shall be added. The nameplate shall state the nature of the conversion and any limitations in interchangeability and ratings. The instruction book number will be stamped on the nameplate.

Each type of conversion shall be treated as follows:

— For high-voltage circuit breakers or G&T device conversions covered by 6.1.4.2 and 6.1.9, the original manufacturer's ratings shall be marked "Converted by" as shown in 8.1 or 8.2, if the ratings of the conversion are not changed.
— For low-voltage circuit breaker conversions covered by 6.1.5, the original nameplate shall be marked "Converted by" as shown in 8.1 or 8.2, if the ratings of the conversion are not changed.
— For switchgear conversions covered by 6.2, the original nameplate remains valid with requirements in 8.3 also followed. Additionally, when only individual vertical sections are converted in any multiple switchgear lineup, the additional nameplate shall list the frame(s) that were converted, if the ratings of the conversion are not changed.

8.1 Individual interrupters

For conversions utilizing individual interrupters, such as in item a) in 6.1.4.2, a conversion nameplate shall be added near or adjacent to the original nameplate, including the words "Converted by" with the name of the organization performing the conversion, address, identification number, date, and all rating information in accordance with the nameplate requirements of IEEE Std C37.04-1999 and IEEE Std C37.13-1990, whichever is applicable.

8.2 Modular assemblies

For conversions utilizing modular assemblies, such as in item b) in 6.1.4.2, the additional conversion nameplate of the modular assembly manufacturer shall be provided on the unit, including the name, address, identification number, date, and all rating information, with an additional nameplate added to the circuit breaker near or adjacent to the original nameplate, including the words "Converted by" with the name of the organization performing the conversion, address, identification number, and date, in accordance with the requirements of IEEE Std C37.13-1990, IEEE Std C37.14-1999, or IEEE Std C37.04-1999.

8.3 Others

For all conversions, except as covered in 8.1 and 8.2, an additional conversion nameplate shall be added near or adjacent to the original nameplate, including the words "Converted by" with the name of the organization performing the conversion, address, identification number, new instruction book number, date, and nature of the conversion in accordance with the requirements of IEEE Std C37.13-1990, IEEE Std C37.14-1999, IEEE Std C37.04-1999, IEEE Std C37.20.1-2002, IEEE Std C37.20.2-1999 or IEEE Std C37.20.3-2001.

9. Manuals

Installation, field test, maintenance, and renewal parts instruction manuals complete with drawings that cover the assembly/equipment installed or revised in the conversion process shall be provided. The manual shall include the expected electrical and mechanical interfaces between the converted circuit breaker and the compartment components including the component mounting inside the cubicle and the adjustments to ensure that they function together. This will include appropriate servicing and test methods and acceptance criteria of circuit breaker compartment mounted equipment such as interlocks and MOC switches to assure proper operation.

The converted circuit breaker instruction manual shall state any limitations in MOC or TOC switches.

The instruction manual shall state whether the converted circuit breaker is or is not interchangeable with non-converted circuit breakers. Where converted circuit breakers are not interchangeable with non-converted circuit breakers, the instruction manual shall indicate interchangeability limits.

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10. Recommended conversion design verification form

The organization verifying that the conversion conforms to this standard shall:

a) Generate a complete tabulation of specific design qualification tests required by the C37 standards if this assembly after the conversion were a completely new design or developed circuit breaker or switchgear assembly as appropriate.
b) For each of these required tests, the specific test that was completed on the assembly after the conversion shall be identified or indication provided that the test was not required, with technical justification provided. The name, position, and responsible organization of the individual making this decision shall appear beside each line of the tabulation of tests with the approval date.
c) The conversion design verification form shall include the above information and identify the product as well as the engineering approval of the conformance. The document shall be issued as a controlled drawing and shall be permanently available for review upon request. The drawing number shall be included on the converter's nameplate.

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Annex A

(informative)

Clarification of conversion processes

A.1 Introduction

This annex is provided for guidance in the design verification of the converted power switchgear equipment. It provides additional guidance regarding conversion examples and the minimum testing required for design verifications.

The owner of any power switchgear equipment to be converted shall plan and define responsibilities to assure that all components of the assembly are serviceable and coordinated, with particular emphasis on ratings, mating connections (such as those for primary current and secondary control), and all interlock functions and adjustments. In some cases such as replacing breakers with fused drawout contactors, the primary circuit protection schemes and dielectric withstand levels may require change.

It is important to recognize that production/field tests do not provide design verification. Design verification can only be accomplished by design testing and technical evaluation.

A.2 Scope

This annex covers the power switchgear equipment conversions outlined in the basic standard. Clauses 1, 2, 3, 4, and 7 are sufficiently explained in the basic standard; however, Clause 6 has been expanded as a guide to ensure that conversions are design-verified as intended. Details included will be helpful regarding different conversion possibilities and in performing the test verification. However, the design tests specifically listed should not be interpreted to be the only tests necessary for the design verification.

A.3 Circuit breakers

A.3.1 Frames (see 6.1.1)

The circuit breaker frame, if retained, should be carefully inspected. Some minor drilling and cutting is permissible, followed by repainting or plating as necessary. However, since other parts will probably be converted, the modified (converted) frame should be tested as part of the total conversion. Design testing shall include mechanical endurance tests to the “between servicing level” and momentary tests to ensure that the mechanical durability of the altered frame has not been reduced. Interlocking and auxiliary functions shall be proven by racking tests and mechanical endurance tests in a switchgear enclosure.

A.3.2 Insulation structure (see 6.1.2)

The insulation structure is critical and any change such as substitution of different materials or a different configuration requires material qualification for flame resistance and tracking, with design testing to include momentary, dielectric withstand, and mechanical endurance tests. It should be noted that insulation testing to determine long time endurance in practical field environments requires evaluation beyond simple dielectric withstand tests.

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A.3.3 Contacts, supports, and primary disconnecting devices (see 6.1.3)

Any alteration in the original design of the contacts, contact structures, contact supports, primary disconnecting devices, or in material content or plating can affect overall performance and requires design verification. Design testing should include close-and-latch, short-circuit current interrupting, and mechanical endurance tests. A continuous-current test should be performed if the alteration modifies the current path, increases the electrical resistance of the current path (as compared to the original design value) or reduces the effective cooling airflow.

A.3.4 Medium- and high-voltage arc-interrupting structures (see 6.1.4)

This subclause is sufficiently outlined in the standard. However, it is stressed that conversion of arc-interrupting structures creates a new design and complete design testing is required.

A.3.5 Low-voltage arc interrupting structures (see 6.1.5.1)

This subclause is also sufficiently outlined in the standard. It is stressed that conversions of arc-interrupting structures create a new design and complete design testing is required.

A.3.6 Fuse replacement (see 6.1.5.3)

Replacing fused low-voltage power circuit breaker current-limiting fuses with a different design fuse, though mechanically the same dimensions, requires design testing. There may be mechanical blocking/rejection means, thermal, peak-current let-through, and crossover current differences. Design testing should be conducted to include, at the least, a continuous-current test and short-circuit current close-open interrupting tests at both the maximum short-circuit current rating of the fused circuit breaker and at the 635 V short-circuit current rating of the unfused circuit breaker.

When adding current-limiting fuses to a previously unfused circuit breaker to increase its short-circuit current capability, the proper mechanical mounting needs to be developed with design verification of the mechanical alterations and to prove the dielectric withstand, continuous and short-circuit current capabilities, regardless of the fuse continuous current rating.

A.3.7 Direct-acting ac overcurrent trip devices (see 6.1.5.4)

Design verification is required in accordance with IEEE Std C37.13-1990 and ANSI C37.17-1997 for basic design parameters, and ANSI C37.50-1989 for basic test parameters. Each frame size converted circuit breaker, unfused or fused, shall be design tested in accordance with the concepts in 3.9.4.3 and 3.9.4.4 of ANSI C37.50-1989, but at both the minimum and maximum sensor ratings at the energy input level corresponding to the actual system voltage on which the converted circuit breaker is applied. The corresponding short-circuit current is listed in ANSI C37.16-2000 for that voltage. For fused circuit breakers, this is in addition to the testing required in 6.1.5.3.

All electronic direct acting overcurrent trip systems used shall be adapted, mounted, and design tested on the circuit breaker. Production tests shall be carried out on each converted breaker.

Some low-voltage circuit breakers tripping devices take advantage of a making release device, therefore meeting the requirements of 3.5.9 of ANSI C37.50-1989 “except when equipped with instantaneous tripping elements during closing.” When installing new trip devices, which are not equipped with a making current release, the converter must conduct short-time current tests in accordance with ANSI C37.50-1989. It should not be assumed that all circuit breakers have been tested to the short-time duty cycle specified by ANSI C37.50-1989.

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A.3.8 Low- and medium- voltage fused ac contactors

When circuit breakers are converted using modular ac contactors, they must always be fused to meet or exceed the short-circuit current capability of the metal enclosed switchgear in which they will be used. An unfused contactor does not have the current withstand capabilities of a circuit breaker, and thus always needs current limiting fuses added to provide protection for maximum short-circuit levels and overload currents exceeding the capability of the unfused contactor itself. Since contactors do not have the full capabilities of a circuit breaker, contactor conversions must be technically evaluated and design-verified (including testing) to assure the proper rating and application for each particular power switchgear equipment conversion application.

While design and production testing of fused ac contactor conversions is not covered in the referenced standards, it is possible to apply some of the fused circuit breaker testing principles outlined in ANSI C37.50-1989. These basic principles are valid for both low-voltage and medium-voltage contactor conversions.

The endurance ratings of modular unfused ac contactors vary widely among manufacturers, and it is impractical to perform endurance (open / close) tests to the ultimate capability of the contactor. However, the converter should perform mechanical (no-load, open / close) tests of the complete conversion in the switchgear cell, to the requirements of the relevant standards. For medium-voltage contactor conversions, the test should conform to clause 27 of UL 347 (1993) (6000 operations). For low-voltage contactor conversions, the test should conform to clause 43 of UL 508 (1999), with the exception that the tests should be conducted as no-load operations and the minimum number of operations should be 6000. For either medium-voltage or low-voltage, “operation” means one complete sequence of a close action followed by an open action.

A.3.9 Addition to, or change in, power fusing of switches used in metal-enclosed switchgear

Metal-enclosed interrupter switchgear generally utilizes the load-break interrupter type switches, which may be unfused or fused, with either the expulsion or current-limiting type of power fuse. After installation and years of service, circumstances may require some conversion due to available short-circuit current increase or for changed protection needs of individual circuits

Any conversion of a qualified design unfused switch to a fused configuration requires many design changes and design verification. The converter must consider the short-circuit current rating of the converted design, the continuous current temperature limits, dielectric requirements, enclosure mechanical strength, and the like. The conversion must also consider the short-circuit current withstand capability of the basic unfused switch, to be sure the current level prior to fuse interruption will not damage the switch.

There are three basic types of conversion of fused switches to use a different size or type of fuse other than in the original qualified design. Conversion to a smaller fuse of the same type and model requires no design verification other than that related to mechanical fit. Conversion to larger fuse of the same type and model requires verification of short-circuit withstand, continuous current temperature rise, dielectric capability, and enclosure integrity. Conversion to a fuse of a different type or model requires verification of short-circuit current withstand, continuous current temperature rise, dielectric capability, and enclosure integrity. The user must also recognize that substitution of expulsion fuses in place of current-limiting fuses may have system protection implications, since the expulsion fuse does not have a current-limiting characteristic. Replacing an expulsion fuse with a current limiting fuse may have system surge protection implications due to associated voltage transients and may require arrestors with a higher maximum continuous operating voltage (MCOV) if this is consistent with dielectric coordination of system insulation components.

A.3.10 Mechanism parts and control wiring (see 6.1.6)

When mechanism parts are replaced with parts different in material, material hardness, or bearing design, for example, a mechanical endurance test must be conducted. Closing and tripping speeds and forces can also be affected and should be checked.

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A.3.11 Low-voltage and medium-voltage drawout parts, racking mechanisms, interlocking and other operational functions (see 6.1.7)

When worn or broken parts are replaced with parts different in material, material hardness, or bearing design, design testing shall be conducted. A major alteration to the drawout system could affect the hold-in capability of the circuit breaker under maximum short-circuit current conditions and should be tested.

When the conversions covered in item b) in 6.1.4.2 are made and redesign of the interlocking is necessary, design testing shall be conducted in an enclosure to ensure interchangeability of the converted circuit breaker in its own vertical section, as well as in other sections as necessary (see 6.1.7.1).

Operating functions for MOC switches or TOC switches shall be provided. Conversions described in item a) of 6.1.4.2 generally utilize existing functions. However, for conversions described in item b) of 6.1.4.2, it may be necessary to increase the number of auxiliary switches and/or the means to operate the existing MOC switch. This would require changes to the blocking/rejection interlocks and also design verification (see 6.1.7.2).

A.3.12 Control circuit coordination (see 6.1.8)

There may also be control schematic or operating characteristic changes during the conversion process that result in incompatibility of the converted product with the non-converted configuration. IEEE Std C37.20.1-2002 and IEEE Std C37.20.2-1999 do not require blocking for various types of control schemes. If the conversion implementation process results in both converted and non-converted switchgear to be located at or available to the same facility, special attention by the user and converter may be necessary to avoid hazardous operating conditions.

If required, a label shall be installed on the circuit breaker and the compartment, to warn of control circuit coordination. The instruction books shall also warn of this characteristic. A typical example might be as follows:

Warning: The controls circuits on this device may not fully function in all compartments. It is essential that complete compatibility be established prior to inserting this breaker into an energized primary circuit.

A.4 Switchgear vertical sections

A.4.1 Basic vertical section (see 6.2.1)

The basic vertical section, if retained, should not have the materials and weldments changed. Some minor drilling and cutting is permissible, followed by repainting as necessary. However, any major alteration should be tested as part of the total conversion with design testing coordinated with the circuit breaker changes. Testing shall include mechanical endurance, short time, and momentary tests to ensure suitability of the altered section. This should include the circuit breaker hold-in mechanism if altered. Interlocking and auxiliary functions should be proven by the racking tests.

If the design of the primary disconnect is altered, testing should be correlated with the circuit breaker testing in A.3.3.

A.4.2 Bus, bus connections, and insulation (see 6.2.2)

The switchgear bus, bus connections, and insulation structure design are a balanced mechanical, electrical, and thermal system, and any replacements that are not of the same design and materials, including the bus-joint covers, may require design testing.

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When a complete, newly fabricated vertical section is constructed for expansion of switchgear or as a replacement for a damaged section, any alteration from the original design, including secondary disconnects, shall be design tested. Depending on the alterations made, the design testing conducted should include the following: insulation material properties; mechanical drawout functions and alignment; momentary current; continuous current; and dielectric withstand capability.

If the design of the primary disconnect device is altered, or the basic circuit breaker rating is increased, dielectric withstand, momentary current withstand, short-time current withstand, and possibly continuous-current tests shall be made in a switchgear enclosure.

A.4.3 Low-voltage and medium-voltage drawout parts, racking mechanisms, interlocking and other operational functions (see 6.2.3)

These basic functions shall be retained and matched to the existing or converted circuit breaker with interchangeability and design testing conducted.

A.5 Additional MOC switch design verification

The design of a MOC switch for use with an air-magnetic or oil circuit breaker may require much more energy to drive it than the MOC switch for a modern sealed interrupter circuit breaker. The operating mechanism of a sealed interrupter design may not have sufficient reserve power to meet its close and latch rating while operating the maximum number of MOC switch contacts that may be installed in the switchgear vertical section. The highest energy requirement, normally occurring during a circuit breaker closing operation, may result in a stalled circuit breaker mechanism or intermittent contact making when closed on a high fault.

Design verification:

- The maximum energy required for closing shall be determined by the converter with an adequate and stated margin to allow for practical field conditions when the lubrication may not be ideal. The justification for the adequacy of margin shall be stated.
- The MOC switch assumed shall be stated with clear limitations of the number of contacts and the service condition of the complete assembly. If blocking/rejection interlock modifications are required to limit application (e.g., to restrict the number of MOC switch contacts or energy required), the revised blocking/rejection interlocks shall be provided.
- Travel curves for both opening and closing shall be taken which show velocity, timing, rebound, and bounce within accepted limits as defined and proven by power testing for the assembly.
- No load endurance testing to at least the “between servicing” intervals shown in ANSI C37.06-2000 or ANSI C37.16-2000 shall be conducted with no mechanical deterioration of any of the parts of the assembly which would prevent the breaker assembly from immediately performing its rated duty cycle.
- Minimum short-circuit testing shall include closing on maximum asymmetrical short circuit current in accordance with the requirements of ANSI C37.50-1989 or IEEE Std C37.09-1999, and shall include a successful opening operation after a cooling period following a full rating closing operation.

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A.6 Typical information to be documented for a conversion

Specific Information of Conversion from Converter:

Technical Authority for all aspects of Conversion

Name: _____

Address: Street:_____

City:_____ State:_____ Zip: _____

Contact: Name:_____ Phone:_____

Fax:_____ E-Mail:_____

Design Verification Drawing Number: _____Rev #_____ Date_____

Note: Certified test data and Design Verification to be available from above Technical Authority.

Specific Intent of Conversion:

Completed Conversion Ratings:

Current Rating: Continuous ____ A, Interrupting ____ kA, Close and Latch ____ kA

Voltage Rating ____ V,

Short Circuit ____kA

Close and Latch ____kA

units of current to be stated i.e. rms amps, peak amps

Arc Chute Replacement: Manufacturer_____ Part Number_____

Fuse Replacement or Addition

Manufacturer:_____Type:_____ CAT #_____ Voltage ____ V, Continuous Current _____A, Interrupting Rating _____kA

Trip Unit Replacement

Manufacturer of Conversion Kit_____

Type_____ Model_____

Power Supply: N/A, Internal ____ V ac dc, External ____ V ac dc

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Interrupter Replacement

Interrupter Manufacturer_____

Model _____Part Number_____

Fuses Required: Yes No *See above for fuses installed*.

Interrupter Replacement with Modular Assembly

Modular Unit Manufacturer _____

Model_____Part Number_____

Voltage Rating ____ V, Frequency: 60 Hz. 50 Hz.

Trip Coil: Manufacturer_____ Part Number _____ Volts ____ ac dc

Close Coil: Manufacturer: _____ Part Number _____ Volts ac dc

Charging Motor: Manufacturer. _____Part Number _____Volts ____ ac dc

Latching Mechanism: YES NO, Aux. Contacts on circuit breaker: ____ a, ____b

Wiring Diag. Number

Trip Functions: LT ST INST. G, CT or Sensor Rating_____

Switchgear Modification Required: YES NO,

Other Breaker Modifications: List Separately

Switchgear

Replace or Upgrade Bus: Material: Al Cu, Voltage Rating: ____ V

Current Rating: Continuous: ____A, Short Circuit: ____ kA, momentary_____kA

Insulation Material _____

Racking Mechanism Modifications:

Describe: _____

MOC Replacement: Manufacturer: _____ Part No. _____

Contacts: ___ a, ___ b Note each cell must be specified

TOC Replacement: Manufacturer: _____ Part No. _____ Contacts: ___ a, ___ b

Barrier Modifications: Describe _____

Insulation Modifications: Describe _____

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Typical Information to be Provided by Customer/User to the Converter:

Name: _____

Address: Street _____City: _____State: _____ Zip_____

Contact: Name: _____ Phone:_____

Fax: _____ E-Mail:_____

Date of Information_____

Original Equipment Information Provided by Customer, Obtained by Converter Inspection

Circuit Breaker

Manufacturer: _____Type: _____Model: _____ Voltage: _____V
Continuous Current: ____ A, Short Circuit Rating: ____ kA, ____MVA
Control Voltage: Trip _____ AC DC N/A, Close_____ AC DC N/A
Number Aux contacts wired out from breaker _____a _____b
Shunt Trip: Yes No,Undervoltage Trip: Yes No
LV Trip Unit
Manufacturer: _____Type: _____Model:_____
Trip Functions: LT ST I G, CT or Sensor Rating: _____

Fuse
Manufacturer: _____Type:_____Cat #: _____
Voltage: _____ V, Continuous Current: _____ A, Interrupting Rating: _____ kA

Switchgear

Manufacture: _____ Type:_____Model:_____
Voltage: _____ V, Main Bus Rating: _____ A, Short Circuit Rating: _____ kA
Number Compartment Contacts: N/A, MOC: ___a ___b
TOC: ___ a, ___b

Modification To Be Performed:

LV Circuit Breaker

Arc Chute Replacement
Main or arcing contact replacement
Trip Unit Replacement: Preferred Manufacturer:_____ Model:_____
Cat. No.: _____ Trip Elements: LT ST I G
Change Air Magnetic Contacts to Sealed Interrupter:
Load Characteristics: Motor: I_{FL} ____A, I_{LR} _____A, Fixed: _____ A, Other: Describe
Open Fuse Trip Device: Yes No, Shunt Trip: Yes No, Latched Interrupter: Yes No
Switchgear Modification Required: Yes No Converter to Determine

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MV Breaker

Arc Chute Replacement
Bushing Replacement
Interphase Barrier Replacement
Trip Coil Replacement
Close Coil Replacement
Charging Motor Replacement
Change Air Magnetic Contacts to Sealed Interrupter:
Load Characteristics: Motor: I_{FL} ____ A, I_{LR} _____ A, Fixed: _____ A,
Other: Describe_____

_____

Switchgear Modification Required: Yes No Converter to Determine

Switchgear

Bus Modification: Rating, Insulation, Supports, Other Components
Convert compartment or section for new type breaker
Modify or Change MOC and/or TOC
Control wiring changes
Convert Section for Retrofill
PT or CPT switch changes

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